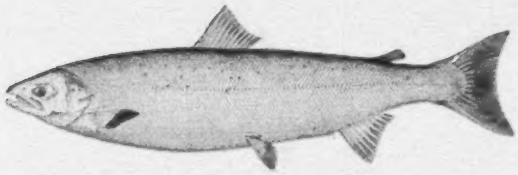
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Gulf Region
Canadian Science Advisory Secretariat
Science Advisory Report 2014/057

STOCK STATUS OF ATLANTIC SALMON (SALMO SALAR) IN DFO GULF REGION (SALMON FISHING AREAS 15 TO 18) TO 2013



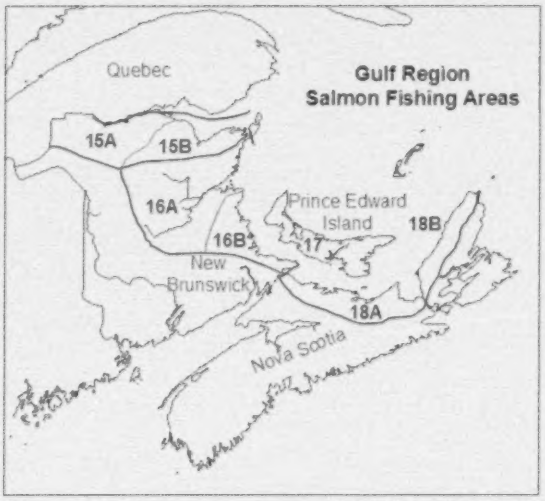


Figure 1: Salmon fishing areas (SFA) in DFO Gulf Region.

Context:

Atlantic salmon (Salmo salar) is broadly distributed in most rivers of the southern Gulf of St. Lawrence and is exploited by aboriginal communities and in recreational fisheries. The last assessments of stock status of Atlantic salmon were completed after the 2011 return year (DFO 2012). COSEWIC concluded that all the salmon populations from the southern Gulf of St. Lawrence and those in the Gaspé region of Québec (zones Q1 to Q3) were one designatable unit and assessed its status as "special concern" (COSEWIC 2010).

In support of the Gulf Region Integrated Fisheries Management Plan for Atlantic salmon, DFO Fisheries and Aquaculture Management (FAM) requested an assessment of the status of the Atlantic salmon stocks in DFO Gulf Region to 2013. The assessments were reviewed during a regional peer review meeting held in Moncton (N.B.) during February 26-27, 2014. Participants at the meeting included DFO Science and FAM from Gulf Region, aboriginal peoples, watershed associations, provincial governments, and conservation organizations. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Atlantic salmon in DFO Gulf Region are harvested in Aboriginal Food, Social and Ceremonial (FSC) fisheries and in recreational fisheries. All recreational fisheries for large (>= 63 cm fork length) salmon are mandatory catch-and-release.
- Sixty percent of the 126 rivers with defined conservation egg requirements are small, with conservation requirements of less than 0.5 million eggs, equivalent to about 100 large salmon. Only four rivers have conservation egg requirements that exceed 15 million eggs each.
- Returns of large salmon to rivers in Gulf Region in 2012 were among the lowest on record in the major index rivers monitored in SFAs 15 (Restigouche), 16 (Miramichi) and 18 (Margaree). Returns in 2013 were at approximately the same levels as those estimated in 2012 in the Margaree River (SFA 18) and the Miramichi River (SFA 16) but were improved in the Restigouche River (SFA 15) from 2012. Returns of large salmon to Gulf Region overall in 2012 and 2013 were estimated to be 38,000 and 34,000 fish, respectively. This follows on the estimated 75,000 large salmon in 2011, near record for the 1970 to 2013 time series.
- Small salmon returns for Gulf Region in 2012 and 2013 were estimated at 18,000 and 24,000 respectively, the lowest and second lowest values of the time series beginning in 1970. This follows on the high return in 2011 of about 73,000 fish which was near the highest levels estimated since 1994 but low relative to the returns estimated during 1985 to 1993 (85,000 to 190,000 fish) and in several years during the 1970s.
- Conservation requirements, in terms of eggs from all size groups, were not met in 2012 with the exception of the Margaree River (SFA 18). In 2013, conservation requirements were met or exceeded in all assessed rivers except for the Miramichi River which achieved only 72% of egg requirements before fisheries removals, 68% after accounting for fisheries removals. This contrasts with 2011 when all assessed rivers in Gulf Region exceeded conservation requirements.
- There are currently about 23 rivers out of 71 rivers historically in SFA 17 (PEI) with confirmed salmon populations. Conservation requirements were met or exceeded in a group of small rivers on the northeast tip of PEI. Salmon production in the remainder of this area is constrained by sediment input from agricultural and other sources, fish kills due to pesticide inputs, water quality problems (low dissolved oxygen, high temperatures), competition with introduced rainbow trout, and habitat fragmentation due to artificial dams and improperly installed culverts.
- Atlantic salmon occupy the majority of rivers in Gulf Region and with exception of some rivers in SFA 17, juvenile abundances are sustained at moderate to high levels. Abundance of adult salmon is constrained by low marine survival, a phenomenon which is widespread for Atlantic salmon stocks from eastern North America.
- Because of undocumented harvests in aboriginal fisheries and incomplete or absent statistics on catches and harvests in the recreational fisheries, assessment of the effectiveness of management measures cannot be provided. Assumptions must be made to assess spawning escapements and compliance with conservation egg requirements.

INTRODUCTION

All rivers flowing into the southern Gulf of St. Lawrence are included in Fisheries and Oceans Canada (DFO) Gulf region (Fig. 1; Appendix Figure 1). Atlantic Salmon (*Salmo salar*) management areas in DFO Gulf Region are defined by four salmon fishing areas (SFA 15 to 18) encompassing portions of the three Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island).

For management purposes, Atlantic salmon are categorized as small salmon (grilse; fish with a fork length less than 63 cm) and large salmon (fish with a fork length equal to or greater than 63 cm). When ages are determined, one-sea-winter (1SW) salmon refers to maiden fish which have spent one year at sea and two-sea-winter (2SW) salmon refers to maiden fish which have spent two years at sea. Repeat spawners are generally found in the large salmon group as repeat spawners grow after going to sea to recondition after spawning and usually return at lengths greater than 63 cm. The majority of salmon in the small rivers of the region return in the fall. Early (May to August) as well as fall runs are important in the larger rivers of the area, including Margaree, Miramichi and several rivers of Chaleur Bay (SFA 15; Nepisiguit, Jacquet) whereas runs to the Restigouche are essentially only early. Bright salmon refer to salmon returning to rivers to spawn during May to November. Kelt salmon (or black salmon) are post-spawned salmon, found in the river in the winter or returning to the ocean in the spring.

Anadromous Atlantic Salmon populations in Gulf Region are comprised of important proportions of 1SW, 2SW, 3SW and repeat spawners. Small salmon, mostly 1SW fish, in SFAs 15 to 18 are the majority males (> 90%) with the exception of early run small salmon in parts of the Miramichi which can be comprised of higher percentages (up to 40%) of females. Large salmon, consisting mostly of 2SW, 3SW and repeat spawners, are predominantly female.

Juvenile salmon spend from two to four years in rivers before migrating to sea as smolts, a migration which takes place in May and June. Salmon from Gulf Region can undertake long seaward migrations, as far as Greenland and occasionally in the northeast Atlantic (east of Iceland) to feed.

ASSESSMENT

Fisheries

All commercial fisheries for Atlantic Salmon in Gulf Region have been closed since 1984. Since then, Atlantic salmon have been harvested by two user groups: Aboriginal peoples and recreational fishers. Since 1998, all salmon fisheries have been prohibited in southeast New Brunswick (SFA 16B; Fig. 2) but salmon are fished in all other Salmon Fishing Areas of Gulf Region.

Aboriginal Food, Social and Ceremonial Fisheries

Aboriginal peoples are given first access to salmon, after conservation requirements, based on communal needs for food, social and ceremonial purposes. Aboriginal fisheries occur annually in the rivers of the southern Gulf of St. Lawrence that are open to salmon fisheries and generally in accordance with agreements and communal fishing licenses (Table 1). Many of the aboriginal fisheries take place in estuaries using gillnets and to a lesser extent trapnets. Salmon are also angled in rivers. In some communities, kelt salmon are allocated and harvested.

Table 1. Allocations (number of fish) by size group of Atlantic Salmon specified within Aboriginal Fisheries Agreements for 2012 and 2013 by Salmon Fishing Area and when appropriate by individual river.

SFA (River[1])	Small salmon		Large salmon		Small or large	
	2012	2013	2012	2013	2012	2013
SFA 15A (Restigouche)	530	530	610	610	na	na
SFA 15B	525	525	0	0	na	na
SFA 16A (Miramichi and Tabusintac)	11,832	11,832	1,304	1,304	na	na
SFA 16B	Closed since 1998					
SFA 17	450	0	450	0	na	na
SFA 18A[2]	105	305	187	347	30	30
SFA 18B[2] (Margaree)	135	135	335	335	10	20
SFA 18 (not specified)[3]	na				1,820	1,820

[1] when available, river specific allocations are provided
[2] kelt salmon allowed but numbers not specified
[3] Nova Scotia Native Council has access to 1,820 fish (small and large combined) throughout SFA 18 (no river-specific allocations)

Recreational fisheries

A provincial licence specific to Atlantic Salmon is required to fish for salmon in all areas except SFA 17 (PEI) where Atlantic Salmon is identified in the general fishing licence (but no salmon can be retained). Only fly fishing with artificial flies is permitted in the recreational salmon fishery. The angling season for salmon in Gulf Region varies among and within SFAs but generally begins in mid-April for the kelt fishery and closes at the end of October in parts of SFA 18. All recreational fisheries for large salmon are mandatory catch-and-release. All retained small salmon must be tagged with a single-use carcass tag which is provided with the purchase of a salmon angling licence.

Retention fisheries for small salmon are regulated by daily and seasonal bag limits (Fig. 2). There is a maximum daily catch and release limit of four fish of any size during the bright angling season and ten during the kelt angling season where this latter fishery is allowed. In New Brunswick, the season bag limit for small salmon is eight (including retained small salmon during the kelt fishery) with a daily retention limit of two or one in the case of the Miramichi River (SFA 16A) and the Nepisiguit River (SFA 15B). The season retention limit for small salmon in SFA 18 (Gulf Nova Scotia) was reduced from eight to four in 2008 with a daily retention limit of two small salmon.

The largest number of salmon licences are issued in New Brunswick followed by Nova Scotia and Prince Edward Island (Table 2). In 2011, 23,317 licences were issued in New Brunswick and the total number of small salmon tags issued was just over 157,000. For Nova Scotia, 2,491 Atlantic Salmon licences were issued in 2011 for a combined total retention tags of 9,964, about half the number of tags issued prior to 2008 (Table 2). There was no Atlantic Salmon licence issued in Prince Edward Island in 2013.

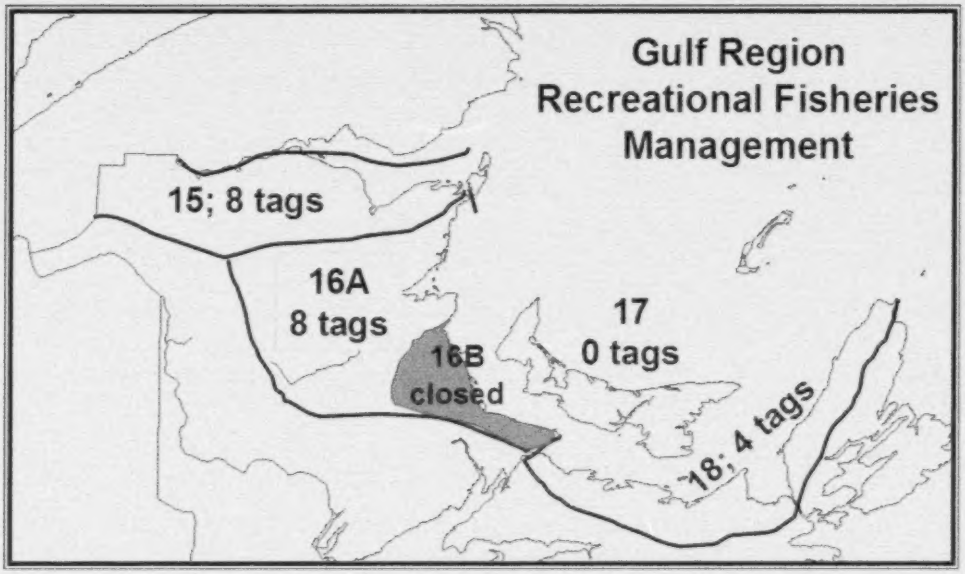


Figure 2: Recreational fisheries management in Gulf Region in 2013 showing season retention limits for small salmon by Salmon Fishing Area.

Table 2. Number of Atlantic Salmon recreational fishing licences and the total number of carcass tags issued by province for the retention of small salmon between 2009 and 2013. The number of tags per licence can vary by licence type for New Brunswick.

Province	Type	2009	2010	2011	2012	2013
New Brunswick	Licences	23,939	22,507	23,459	23,221	22,685
	Tags	164,038	153,352	157,466	158,904	153,624
Nova Scotia	Licences	2,394	1,938	2,491	2,314	2,491
	Tags	9,576	7,752	9,964	9,256	9,964
Prince Edward	Licences	129	143	204	0[1]	0[1]
Island	Tags	0	0	0	0	0

[1] For Prince Edward Island, no recreational Atlantic Salmon licence was issued and fishing for salmon, but without retention, was regulated under the general fishing licence.

Catches and harvests

A distinction is made between the terms catch and harvest. Harvest refers to salmon which are deliberately retained in fisheries and include small salmon retained in recreational fisheries and small salmon and large salmon retained in aboriginal fisheries. Catch includes retained fish and salmon which are caught and released in salmon recreational fisheries.

Harvests from aboriginal fisheries include only values reported by the aboriginal peoples to DFO. Reports in all SFAs are incomplete.

For recreational fisheries, catch and harvest data are obtained using various methods. Angling catch data are available from the two largest rivers of SFA 15; the Restigouche River (SFA 15A) and the Nepisiguit River (SFA 15B). Catches in the Restigouche River are based on lodge catch reports compiled by DFO Science Branch and Crown Reserve angling catches compiled by the provinces of New Brunswick and Quebec, and exclude catches from the public water. There is limited public water in the Restigouche River but angling effort in the few public water stretches can be quite high in some years, including 2011. Angling data from the Nepisiguit River are

compiled by the Nepisiguit Salmon Association through a creel survey and are adjusted based on observations from previous years for unsurveyed periods and sections of river.

Table 3. Reported harvests of small salmon and large salmon by SFA in aboriginal fisheries for food, social and ceremonial purposes.

Salmon Fishing Area	Size	2009[1]	2010[1]	2011[1]	2012	2013
SFA 15	Small	na	na	113	44	31
	Large			513	432	430
SFA 16	Small	na	2,895	2,130	1,395	1,507
	Large		787	526	443	659
SFA 17	Small	0	1	0[2]	3 small and large	0
	Large	0	0	0[2]		
SFA 18	Small	na	na	na	157 small and large and 98 kelts	85 small and large
	Large	na	na	58		

[1] Data are incomplete or not available
[2] Only one of two aboriginal groups reporting

For SFA 16, catch and effort data were available to 1995 (and in 1997) from a provincial post-season mail-out survey to a subset of licenced anglers. The last year of the survey was 1997 and since then, no complete recreational catch and effort data are available. The Miramichi is the largest river in SFA 16 and historically accounted for over 90% of the angling catch and effort in this SFA. For assessment purposes, catches for 1996 and the years after 1997 are estimated from average exploitation rates (0.30) based on the 1991 to 1995 period and calculated as angling catches (retained plus released by size group) divided by the estimated returns to the Miramichi River.

In Nova Scotia, anglers receive licence stubs with their licences. The anglers are required to record days fished (effort) and fish captured (retained and released) by river. At the end of the fishing season, anglers must return their licence stubs to the provincial authority but not all licence holders do so. Data are compiled by DFO Science Branch. The response rate in previous years has varied from 25% to 40% per year and higher return rates are achieved only with reminder letters. In 2012, 886 licence stubs (out of 2,314) were returned by anglers in Nova Scotia, a 38% response rate, after reminder notification. In 2013, 513 licence stubs (out of 2,491) were returned by anglers in Nova Scotia, a 21% response rate, before reminder notification. Estimates of total catches and harvests are obtained by raising the returned licence stub catch and effort values to total licence sales.

Estimated small salmon catch in the Restigouche River (NB) in 2013 increased from 2012, was below the means of previous decades, but was within the range (1,372 to 6,193) of values recorded during 1984 to 2013. The large salmon catch in 2013 increased from 2012 and was above the means of the previous decades when the catches ranged from 1,173 to 4,894 fish. Estimated angling catch in 2013 of small salmon in the Nepisiguit River was lower than 2012 and the large salmon catch was higher than 2012 (Table 4).

Although the 2013 angling data are preliminary for SFA 18, the estimated catches of small salmon and large salmon in 2012 and 2013 were below the 5-year averages in SFA 18A, and well below in SFA 18B.

Table 4. Effort (rod days) and catches (including retained and released fish) by SFA during the bright salmon recreational fishery, 1984 to 2013. In the table, "na" refers to not available. Values for 2013 are preliminary.

Salmon Fishing Area	Statistic	Mean (1984-1994)	Mean (1995-2004)	Mean (2005-2009)	2010	2011	2012	2013
SFA 15A Restigouche River [1]	Effort	10,709	10,589	9,712	9,806	10,431	7,645	9,352
	Small	3,685	3,085	3,298	3,868	4,836	2,054	2,201
	Large	3,149	1,992	2,379	2,099	5,281	2,286	3,840
SFA 15B Nepisiguit River	Effort	na	na	na	na	na	na	na
	Small	880	460	630	976	1,210	1,215	900
	Large	366	300	200	300	620	423	513
SFA 16A Miramichi River	Effort	89,332	na	na	na	na	na	na
	Small	20,124	na	na	15,033 [2]	13,164 [2]	2,497 [2]	3,525 [2]
	Large	9,417	na	na	4,830 [2]	9,318 [2]	4,065 [2]	3,978 [2]
SFA 16B	Effort							
	Small	na			Closed since 1998			
	Large							
SFA 17 [3]	Effort	5,674	4,611	2,721	1,065	2,067	na	na
	Small	1,312	523	159	72	68	na	68
	Large	197	118	61	32	68	na	68
SFA 18A	Effort	3,699	3,371	3,577	3,996	5,959	4,354	5,150
	Small	360	367	354	421	991	260	257
	Large	1,052	663	622	705	2,547	691	661
SFA 18B	Effort	12,556	8,766	8,874	7,361	10,098	4,931	6,500
	Small	675	451	420	444	707	87	157
	Large	1,655	1,220	1,175	1,264	2,924	397	630

[1] For border waters between New Brunswick and Quebec and waters within New Brunswick
[2] Estimates of catch based on catch rate of 0.30 of estimated returns to the Miramichi River
[3] Estimates of catch in 2011 for SFA 17 based on angler card survey with 10% mail-in rate

The mortality associated with catch-and-release fishing varies among the SFAs. For SFA 15, a mortality rate of 6% has been used since 1984 and is considered to account for a higher mortality rate than in other SFAs due to the prevalence of furunculosis (disease) which can contribute to mortalities. A 3% catch and release mortality value is used for released salmon in SFA 16 and SFA 17. A 5% catch and release mortality is applied to angling catches in rivers of Gulf Nova Scotia (SFA 18) because of the history of bacterial kidney disease in Atlantic salmon of the Margaree River.

Estimated losses of small salmon in the recreational fisheries are highest in SFA 16A whereas losses of large salmon are highest in SFA 15A (Table 5).

Conservation requirements

Conservation for Atlantic Salmon is defined as an egg deposition rate of 240 eggs per 100 m² of wetted juvenile rearing habitat area (CAFSAC 1991a). This value is applied to all rivers in Gulf Region with the exception of the Restigouche River for which a value of 168 eggs per 100 m² of wetted area is used. The value for the Restigouche is based on a stock and recruitment analysis of index rivers in the province of Quebec and a reference spawning escapement value that would result in the maximum surplus of fish.

Sixty percent of rivers in Gulf Region are small rivers with conservation egg requirements of less than 0.5 million eggs (Fig. 3). Only a few large rivers (Restigouche in SFA 15A, Southwest Miramichi, Northwest Miramichi and Little Southwest Miramichi in SFA 16A) have conservation egg requirements that exceed 15 million eggs each (Appendix Table 1). At approximately 6,000 to 7,000 eggs per large salmon female and a sex ratio of about 80% female in the large salmon

category, the conservation egg requirements would be met by about 100 large salmon in most of the small rivers.

Conservation requirements are considered to be equivalent to a limit reference point. Management of Atlantic Salmon in eastern Canada and internationally has been based upon a fixed escapement strategy; all fish in excess of the conservation requirements are considered to be surplus and available for harvest (CAFSAC 1991b).

Table 5. Losses (including retained catch and losses from incidental mortality in catch-and-release fisheries) by size group of salmon and by SFA during the bright salmon recreational fishery, 1984 to 2013. Values for 2013 are preliminary.

Salmon Fishing Area	Size	Mean (1984-1994)	Mean (1995-2004)	Mean (2005-2009)	2010	2011	2012	2013
SFA 15A Restigouche River [1]	Small	3,610	2,006	1,504	1,394	1,774	730	855
	Large	233	150	175	138	395	209	292
SFA 15B Nepisiguit River	Small	663	295	347	517	730	533	267
	Large	22	16	12	18	37	25	31
SFA 16A Miramichi River [2]	Small	20,124	7,970	6,451	13,183	11,470	2,014	2,956
	Large	282	174	163	162	307	80	73
SFA 16B	Small	Closed since 1998						
	Large							
SFA 17	Small	599	301	67	2	2	na	2
	Large	0	4	2	1	2		2
SFA 18A	Small	263	204	107	144	252	67	64
	Large	53	33	31	35	127	35	33
SFA 18B	Small	538	212	222	198	273	21	77
	Large	83	61	59	63	146	20	32

[1] For border waters between New Brunswick and Quebec and waters within New Brunswick

[2] Estimated losses for 2010 to 2013 based on assumed catch rates of estimated returns (25% retention rate for small salmon, 5% catch and release rate for small salmon, and 30% catch and release rate for large salmon) and 3% catch and release mortality rate.

Abundance (returns and spawners) of adult salmon by SFA

SFA 15A

Information on adult salmon abundance is available for the Restigouche River only and comes primarily from angling catches and effort as well as end of season spawner counts. Based on an assumed angling exploitation rate of 40%, returns to the Restigouche River (NB) in 2013 were estimated at 9,852 large salmon and 5,545 small salmon (Fig. 4). This assumed angling exploitation rate is similar to that of the Matapedia River (a tributary of the Restigouche River) for which the previous five-year average was 39%. After accounting for losses from fishing, the spawning escapement in 2013 was estimated at 9,370 large salmon, 164% of the spawning requirement (5,700 for Restigouche River NB portion). Based on an angling exploitation rate of 40%, the Restigouche River (NB portion) River has met or exceeded the conservation egg requirement in 7 of the last 11 years (Fig. 5).

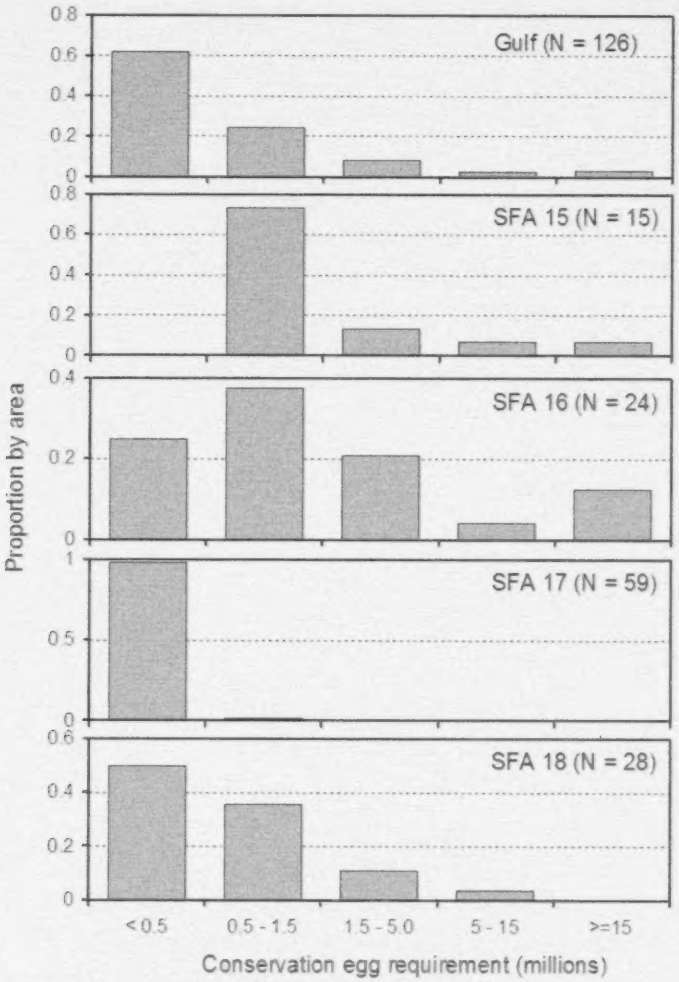


Figure 3. Proportion of rivers within each SFA and for Gulf Region overall with defined conservation requirements by category of conservation egg requirements.

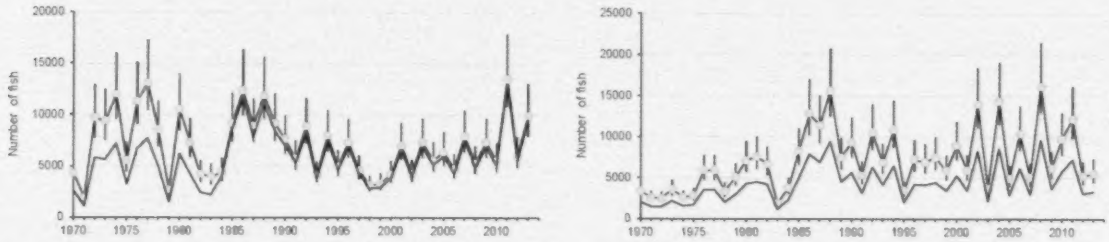


Figure 4. Returns (grey circle are for 40% catch rate and vertical error bars show range based on catch rates of 30% to 50%) and spawners (solid line for 40% catch rate assumption) based on angling catches of large salmon (left) and small salmon (right) to Restigouche River (NB portion), 1970 to 2013.

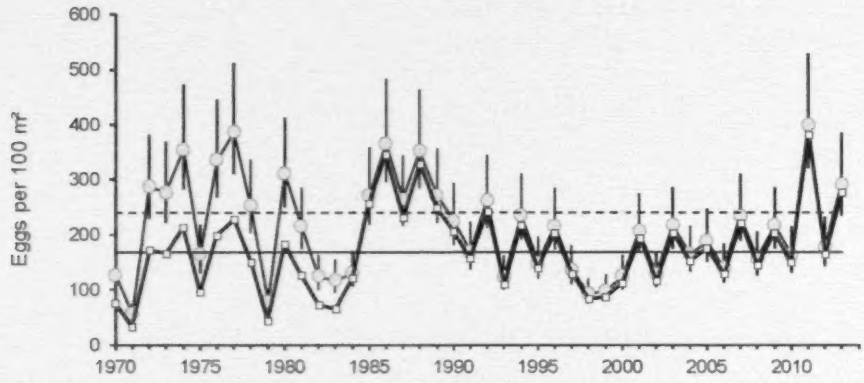


Figure 5. The potential eggs (expressed as eggs per 100 m² of wetted habitat area; total area of 21.6 million m²) by large salmon for the returns (grey circles are assumed catch rate of 40%, error bars show range for catch rates of 30% to 50%) and the spawners (white square symbols for an assumed catch rate of 40%) in the New Brunswick portion of the Restigouche River, 1970 to 2013. The solid horizontal line is the egg deposition rate of 168 eggs per 100 m² presently used to assess attainment of conservation for the Restigouche River. The dashed horizontal line is the egg deposition rate corresponding to 240 eggs per 100 m² used in other rivers of Gulf Region.

Assessments on the Restigouche River are also informed by spawner counts at the end of the season, after all fisheries and inriver losses. End of season spawner counts were conducted in 2013 on two Restigouche (NB) tributaries (Kedgwick and Little Main Restigouche) in late September to early October. Due to high water levels no counts were conducted on the Upsalquitch or mainstem Restigouche. Visibility was generally fair on the tributaries and counts derived from snorkelling should be considered a minimum estimate of spawners. The spawner counts for the Kedgwick were 167 small salmon and 1,318 large salmon, and above the conservation requirement. The spawner counts on the Little Main Restigouche River were 168 small salmon and 755 large salmon, very close to the conservation requirement. Spawners in the Matapedia River (including Causapscal River) were 345 small and 1,884 large salmon, equivalent to 146% of the conservation requirement. The spawners in the Matapedia River have exceeded the conservation requirement every year since 1993. Spawners in the Patapedia River (157 small and 645 large salmon) were 185% of the conservation requirement. The spawners in the Patapedia River have exceeded the conservation requirement every year since 1985.

SFA 15B

For the Nepisiguit River, estimates of returns and escapements based on fence counts are generally incomplete. In recent years, estimates indicated that conservation requirements had been achieved in only 2 of 15 years when the stock was assessed (1982 to 1996). Estimates based on redd counts in late fall indicate that spawning escapement has been around the conservation requirement since 1994. A relationship between large salmon spawners and redds was derived from the years when complete counts of large salmon were obtained at the counting fence. An escapement of 1,900 large salmon (119% of the egg conservation requirement) was estimated from 3,374 redds observed in 2013.

Counts of salmon at a protection barrier near the head of tide on the Jacquet River have frequently been incomplete due to washouts or late installations. Adult abundance in the Jacquet River exceeded the conservation requirement (571 large salmon and 383 small salmon) at the start of the time series (1994 to 1996) but in recent years, its status relative to

conservation is unknown due to frequent washouts. In 2012 a total of 71 large salmon and 198 small salmon were enumerated compared to 2013 when a total of 200 large salmon and 145 small salmon were enumerated. Counts in both these years are incomplete due to washouts.

SFA 16A

The Miramichi River is the largest river in SFA 16 and Gulf Region. Returns are estimated using catches and mark and recapture experiments at monitoring trapnets in tidal waters.

Estimated returns of large salmon to the Miramichi River were 13,590 fish (median; 95% confidence interval of 9,776 to 20,110) in 2012 and 12,540 fish in 2013 (median; 95% confidence interval of 8,544 to 22,750) (Fig. 6). The returns of large salmon in 2012 and 2013 are the second and third lowest values, after 2002, since 1998.

The estimated returns of small salmon were 8,282 fish (95% C.I. 6,083 to 11,080) in 2012 and 11,760 fish in 2013 (95% C.I. 8,523 to 17,440) (Fig. 6). The returns of small salmon in 2012 and 2013 are the lowest returns estimated over the time series beginning in 1971 and followed on two years of relatively good returns in 2010 and 2011 of 49,060 and 45,260 fish, respectively.

Estimates for the two main branches of the Miramichi are available since 1992 (Fig. 6). The returns of large salmon to the Southwest Miramichi River in 2011 were estimated at 27,870 (95% C.I. 17,140 - 58,150), the highest since 1992. Returns of large salmon in 2012 and 2013 of 10,780 (95% C.I. 7,870 - 15,050) and 10,120 (95% C.I. 7,428 - 16,630) large salmon, respectively, were among the three lowest values of the time series. The estimates of returns of small salmon in 2012 and 2013 of 5,586 fish (median; 95% C.I. 3,857 to 8,263) and 7,537 fish (median, 95% CI. 5,020 to 13,370), respectively, were the lowest of the time series, and followed on the high returns of small salmon in 2010 and 2011 (31,080 and 30,320, respectively) (Fig. 6).

The returns of large salmon to the Northwest Miramichi River were essentially similar in 2012 and 2013, estimated at 2,635 fish (median, 95% C.I. 1,816 to 4,034) and 2,342 fish (median, 95% C.I. 1,624 to 3,458) respectively (Fig. 6). These returns are within the range of return estimates to the Northwest Miramichi since 2002 and followed on the higher returns in 2010 and 2011. The estimated return of small salmon to the Northwest Miramichi River in 2012 was 2,623 fish (median, 95% C.I. 2,009 to 3,706) and 4,094 fish in 2013 (median, 95% C.I. 3,238 to 5,538) (Fig. 6). The estimated return of small salmon in 2012 was the lowest of the time series and followed on high returns in 2010 and 2011 (Fig. 6). The 2013 returns of small salmon increased by 58% over 2012 but were the third lowest of the time series.

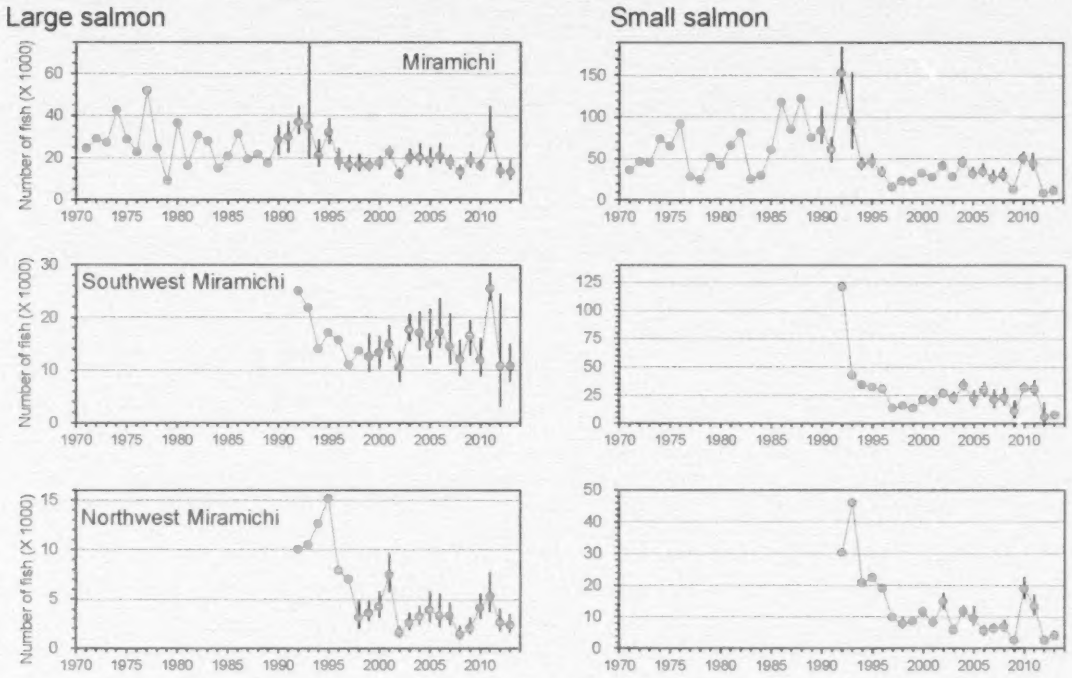


Figure 6. Estimates (median and 5th to 95th percentile range) of large salmon (left column) and small salmon (right column) returns for the Miramichi River for 1970-2013 (upper row), the Southwest Miramichi River 1992-2013 (middle row), and the Northwest Miramichi River 1992-2013 (bottom row).

Catches and counts of large salmon at provincial barriers and crown reserve angling stretches in 2013 were improved over 2012 and above the previous 5-year averages. Small salmon catches and counts at provincial facilities in 2013 were also improved over 2012 levels but less than the previous 5-year means. Although these changes on year at monitoring facilities differ slightly from the estimates of returns, the counts and catches of small salmon and large salmon in 2012 and 2013 were both low relative to the historical values.

Considering the biological characteristics of salmon in 2012 and 2013, the total eggs in the returns of large salmon and small salmon combined were sufficient to attain only 72% of the conservation requirement in 2012 and 2013 (Fig. 7; Table 6). This follows on the high returns in 2011 for which 212% of the conservation requirements were attained in the returns. After accounting for known or estimated removals, the percent of the conservation egg requirement attained was 69% in 2012 and 68% in 2013 (Fig. 7; Table 6). The percentage of the conservation requirement attained in the Southwest Miramichi has been higher in all years since 1996 than either for the Miramichi overall or the Northwest Miramichi in particular (Fig. 7). Despite the better performance of the Southwest Miramichi, the eggs from the returns of small and large salmon combined were sufficient to attain only 83% of the conservation requirements in 2012 and 2013. The percentage of the conservation requirement attained for the Northwest Miramichi was less than 50% in both 2012 and 2013; attainment of conservation has been at or below 50% in most years since 2002 (Fig. 7).

The escapement of salmon to the Miramichi River as a whole was sufficient to meet the egg deposition requirements repeatedly between 1992 and 1996 but only three times (2001, 2004, and 2011) during the period 1997 to 2013. The conservation requirement was attained on the Southwest Miramichi River between 1992 and 1996, and regularly (7 times and 3 marginal

misses) between 1997 and 2013. The Northwest Miramichi River achieved conservation levels between 1992 and 1997 but only twice (2001 and 2011) during the 1998 to 2013 period (Fig. 7).

Table 6. Percentages of the conservation requirements (eggs) attained for small salmon and large salmon combined from the returns and spawners in 2012 and 2013 for the Miramichi River overall, the Southwest Miramichi and the Northwest Miramichi rivers.

River	Year	Percent of conservation egg requirements in the returns	Percent of conservation egg requirements in the spawners
Miramichi River	2012	72	69
	2013	72	68
Southwest Miramichi River	2012	83	81
	2013	83	80
Northwest Miramichi River	2012	48	42
	2013	48	39

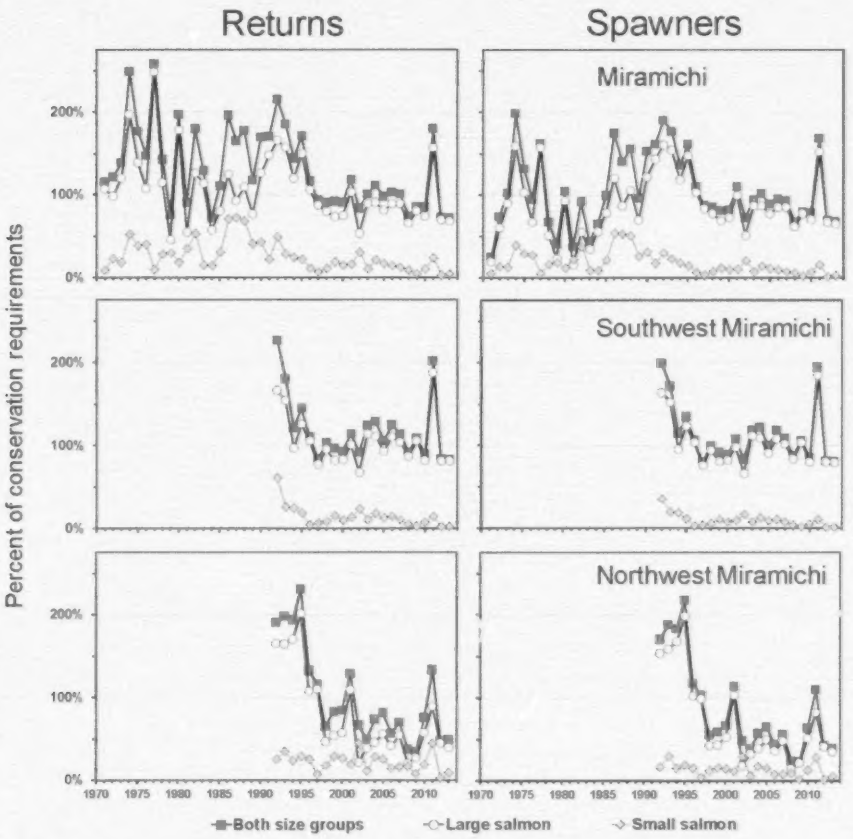


Figure 7. Percentage of the conservation egg requirements achieved for the returns (left column) and the spawners (right column) of large salmon, small salmon, and size groups combined for the Miramichi River overall 1971 to 2013 (upper panel, for the Southwest Miramichi 1992 to 2013 (middle panel), and the Northwest Miramichi 1992 to 2013 (lower panel).

SFA 16B

Monitoring programs for adult Atlantic Salmon have occurred in the Buctouche, Richibucto, and Kouchibouguacis rivers. Assessments of returns of adult Atlantic Salmon to these rivers have not been conducted since 2000 but uncalibrated trapnet catches confirm that adult salmon continue to migrate and spawn in these smaller rivers. Stock status for these rivers is inferred from trends in abundances of juvenile salmon which are described in the freshwater production section below.

SFA 17

Salmon were widespread and abundant in the early historical period in SFA 17 and about 71 rivers are thought to have contained salmon. Salmon decreased in distribution and numbers after European settlement. Juvenile surveys conducted in 2000-2002 and in 2007-2008 found salmon in 28 and 22 rivers, respectively. With an additional river with salmon sampled in 2011, there are currently 23 rivers in SFA 17 with salmon presence confirmed (Appendix 1, 2).

Salmon redds have been surveyed in all current PEI salmon rivers at least once since 1990. On the basis of the most recent redd counts, spawners on PEI total 1,257 salmon, of which 728 were females. These spawners produced an estimated 3.5 million eggs, equivalent to 33% of conservation requirements for the 71 rivers which currently or probably formerly contained salmon, and 71% of the conservation requirements of the 27 rivers which currently contain salmon. Estimated spawning escapements exceeded conservation requirements in eight rivers (Cains, Carruthers, Morell, Cow, Naufrage, Cross, Priest Pond, North Lake), five of these eight rivers are located on the northeast extremity of PEI. Populations in several smaller rivers are very low and reproduction does not appear to occur every year, based on single year classes of juveniles in rivers, and salmon in these rivers are considered at risk of extirpation.

SFA 18A

There are no direct counts of adult salmon in rivers of mainland Nova Scotia (SFA 18A) and catch per unit effort from the angling fishery is used as an index of abundance. Catch of large salmon and small salmon per rod day decreased in River Philip, East River (Pictou) and West River (Antigonish) during 2012 and 2013 compared to 2011 (Fig. 8).

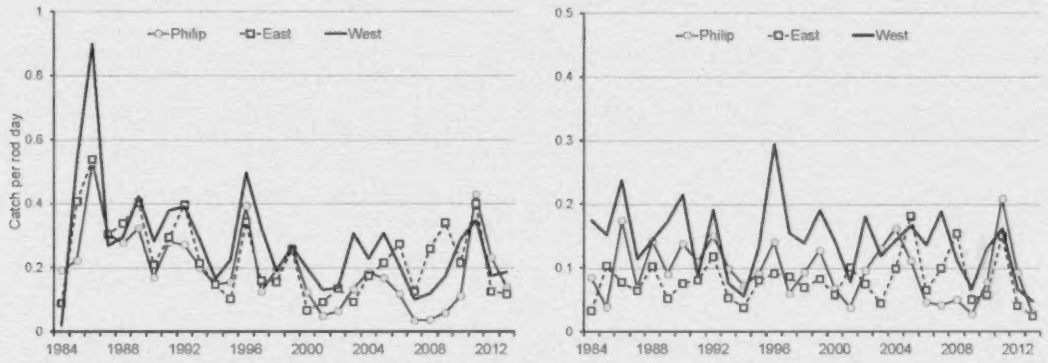


Figure 8. Catch per rod day for large salmon (left panel) and small salmon (right panel) in three rivers of mainland Nova Scotia (SFA 18A), 1984 to 2013. Data for 2013 are preliminary.

SFA 18B

Angling catches of large salmon per rod day of effort in the Margaree River in 2012 and 2013 were low and the catches per rod day of small salmon were near to or at record low values of the time series (Fig. 9). The returns of salmon to the Margaree River are assessed using an estimate of the catchability coefficient in the angling fishery based on years (1988 to 1996) when independent estimates of run size using mark and recapture experiments were available. The estimated return of large salmon to the Margaree River in 2012 was 1,276 large salmon (95% C.I. 1,001 – 1,627), the lowest value over the period of assessment, and 1,715 large salmon in 2013 (95% C.I. 1,345 – 2,186). Large salmon returns and spawners to the Margaree River have exceeded the conservation requirement (1,036 large salmon) every year since 1985 (Fig. 9). The estimated return of small salmon to the Margaree River in 2012 was 269 fish (95% C.I. 183 – 397), the lowest value over the period of assessment, and 363 small salmon in 2013 (95% C.I. 263 – 559).

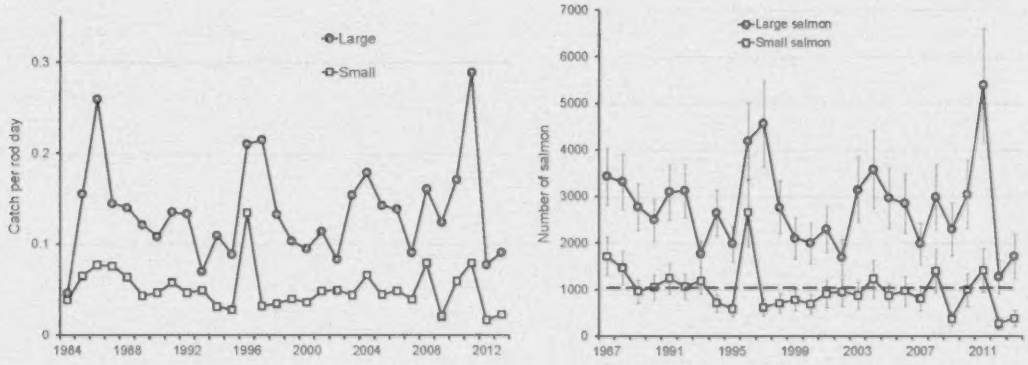


Figure 9. Catch per rod day (left panel) from 1984 to 2013 and estimated returns (number of fish; right panel) for 1987 to 2013 of large salmon and small salmon in the Margaree River (SFA 18B). Data for 2013 are preliminary. The horizontal dashed line in the right panel is the conservation requirement of 1,036 large salmon for the Margaree River.

Gulf Region

Estimates of total returns and spawners of small salmon and large salmon are developed for each SFA and overall for Gulf Region. The estimates are derived from monitored rivers.

Return and spawner estimates for SFA 15 are based on angling catches from the Restigouche River and assumed exploitation rates of 30% to 50% (min. to max. values), with estuary catches added to the estimates of returns. The return and spawner estimates for SFA 15 are derived from the ratio of angling catch in all of SFA15 relative to angling catch in Restigouche River (New Brunswick) (min = 1.117; max = 1.465). The most important Atlantic salmon river in SFA 16 is the Miramichi River which represents 91% of the total freshwater rearing area of SFA 16. Returns to the Miramichi are assessed annually. Returns to SFA 16 are Miramichi returns divided by 0.91. For SFA 17, estimates of returns of small salmon are calculated as retained catch of small salmon divided by exploitation rate. Angler exploitation rates of 0.264 to 0.347 were estimated during 1994 to 1996. Large salmon returns are calculated from small salmon returns and the proportion small as derived from sampled rivers. For 1995 and subsequently, spawners were estimated from redd counts. Returns and spawners to SFA 18 are derived from estimates of returns and spawners to the Margaree River, adjusted for the ratio of the SFA 18 angling catch to the Margaree River catch.

Returns of large salmon to Gulf Region in 2012 and 2013 were estimated to be 28,000 and 34,000 fish, respectively, a large decrease from the near record estimated returns of about 75,000 large salmon in 2011 (Fig. 10). The high returns in 2011 and the large decline in 2012 were estimated in all SFAs, with the exception of SFA 17 (PEI). The continued low abundance of large salmon in 2013 was estimated in SFAs 16 and 18. Small salmon returns for Gulf Region in 2012 and 2013 were estimated at 18,000 and 24,000 respectively, the lowest and second lowest values of the time series beginning in 1970 (Fig. 10). This follows on the high return in 2011 of about 73,000 fish which was near the highest levels estimated since 1994 (Fig. 10). Small salmon abundances in 2012 and 2013 were very low in all SFAs, except for SFA 17.

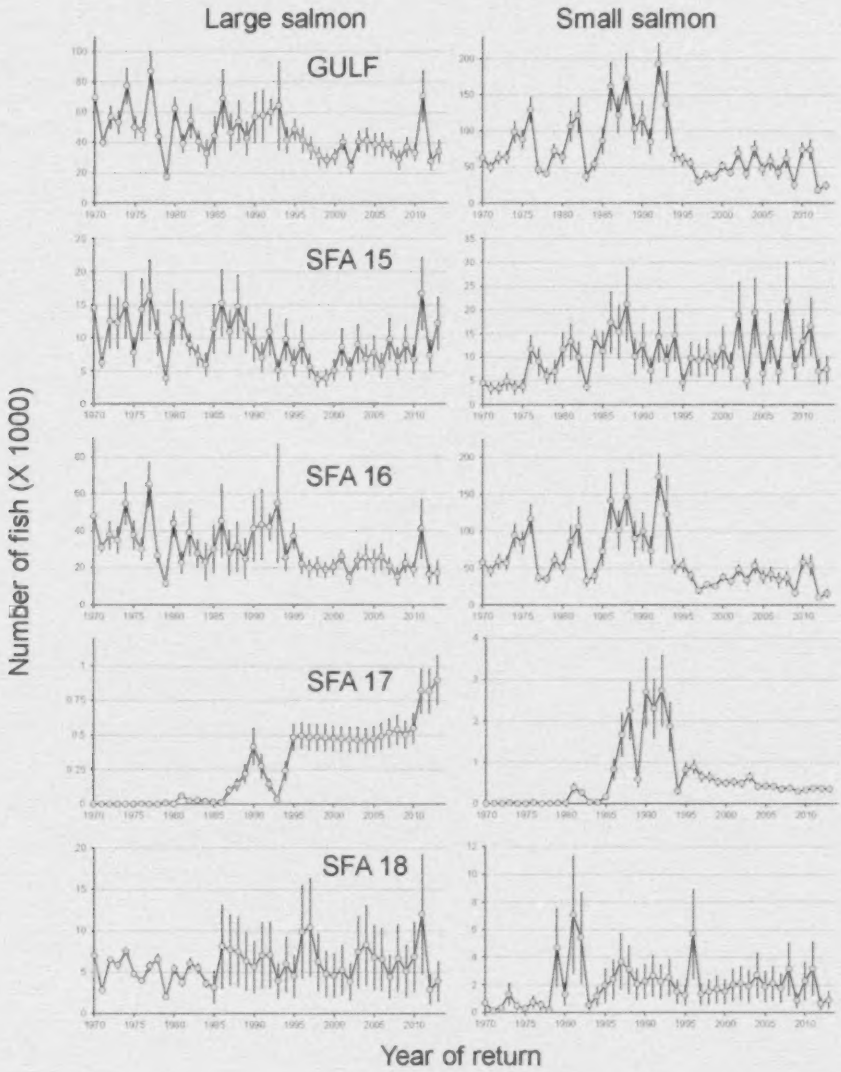


Figure 10. Estimates (median, 95% Confidence Interval range) of total returns of large salmon (left panels) and small salmon (right panels) to each of SFA 15, 16, 17, and 18, and to Gulf Region rivers overall, 1970 to 2013.

Freshwater juvenile production

Indices of freshwater production are derived from electrofishing surveys of juvenile salmon and estimates of smolt production for index rivers. Fixed site sampling for juvenile salmon has been conducted since the 1950s in the Margaree River and most consistently since 1971 in the Miramichi and Restigouche rivers. Abundances at sites, in terms of number of fish per habitat area sampled by age or size group (densities), are obtained using successive removal sampling or by catch per unit effort sampling calibrated to densities. Sampling intensities vary among years and among rivers with more sites sampled in the larger rivers (Restigouche, Miramichi, Margaree). For rivers with long time series, densities are referenced for two time periods, prior to 1984 and post-1984 (or later depending upon the age group) corresponding to the year (1984) when commercial fisheries were closed and the introduction of mandatory catch-and-release for large salmon in the recreational fishery.

SFA 15A (Restigouche)

Juvenile salmon are distributed throughout SFA 15A. In 2013 two to three cohorts (fry, small parr, large parr) were captured at most sampling sites indicating that there had been multiple years of spawning success. Juvenile abundance in the Restigouche River has been monitored annually since 1972. Densities of Atlantic salmon fry, small parr (mostly one-year old), and large parr (mostly two-year and older) all increased post-1984 and remain at moderate levels (Fig. 11). Fry and small parr abundances since 1996 show a decrease whereas large parr show an increase in density (Fig. 11). Results from juvenile salmon surveys in 2008 and 2011, which showed decreased abundance of some age classes, could be biased due to difficult sampling conditions (extremely high water) rather than an indicator of actual lower abundance. All sites sampled have become and remain occupied by juveniles with the exception of some small streams which are prone to periodic blockages to spawners by beaver dams.

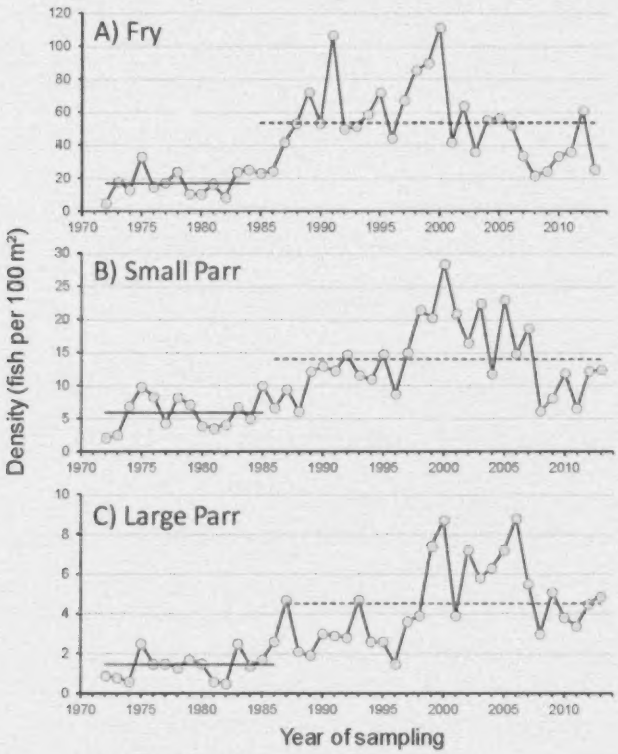


Figure 11. Mean juvenile densities (fish per 100 m²) for fry (A; upper panel), small parr (B; middle panel) and large parr (C, lower panel) for the sites sampled in the Restigouche River (NB waters only, excluding Matapedia and Patapedia rivers), 1972 to 2013. Horizontal solid line and the horizontal dashed line in each panel are the average densities corresponding to periods before and after, respectively, the significant management changes were implemented to the commercial and recreational salmon fisheries in 1984.

SFA 15B

Juvenile abundance in the Nepisiguit River has been monitored annually since 1981 by the Nepisiguit Salmon Association (NSA). Salmon fry densities in the Nepisiguit River have increased since the 1980s whereas parr abundance has remained about the same (Fig. 12). In the exceptional high water years of 2008 and 2011, open site sampling was employed at some locations and resulted in possible underestimates of densities for these years.

Juvenile abundances in the Jacquet River, monitored since 1999, are higher than in the Nepisiguit River and at comparable levels to those of the Restigouche River (Fig. 12). Since 2007, juvenile salmon abundance levels on the Charlo River have been comparable to those of the Jacquet River and the Restigouche River (Fig. 12).

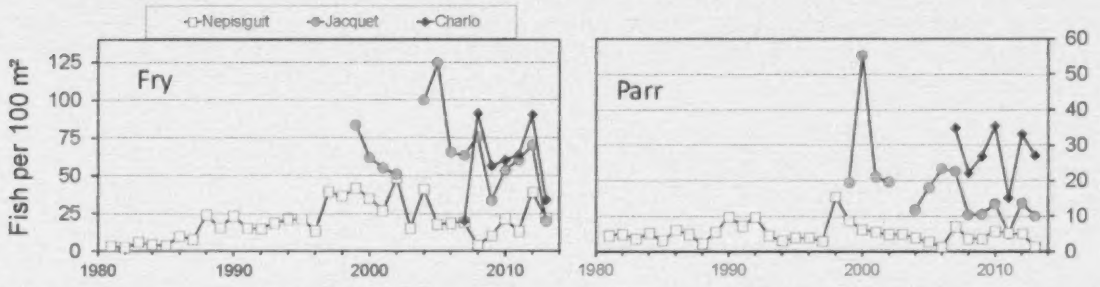


Figure 12. Juvenile densities (fish per 100 m²) for fry (left) and parr (right) for Nepisiguit, Jacquet and Charlo Rivers, 1981 to 2013.

The NSA also conducts juvenile abundance surveys of several other rivers of SFA 15B (Middle, Tetagouche, Bass, Millstream, Nigadoo and Elm Tree rivers). Juvenile abundance in these rivers has been comparable or superior to the Nepisiguit River.

SFA 16A

Densities of Atlantic salmon fry, small parr, and large parr in the Miramichi watershed were summarized according to the four major tributaries (Southwest Miramichi [SW], Renous, Northwest Miramichi [NW], and Little Southwest Miramichi [LSW] rivers). Average juvenile densities were calculated only when four or more sites per large river system were surveyed in a given year.

Salmon fry were captured at all but one of the 56 sites surveyed in 2012 and all of the 30 sites sampled in 2013 which indicates that adult salmon continue to spawn throughout the Miramichi watershed. Average fry densities in 2012 ranged between 45 (Little Southwest) and 132 (Northwest) per 100 m^2 and were above average for each river except the Little Southwest. Above average levels of fry in 2012 correspond to the high spawning escapements, in excess of conservation requirements, in 2011. In 2013, average fry densities were 33 and 57 per 100 m^2 in the Renous and Northwest Miramichi rivers, respectively, consistent with the lower spawning escapements attained in 2012 (Fig. 13).

Average small parr densities varied from 8 (Little Southwest) to 23 (Northwest) per 100 m^2 in 2012 and 21 to 41 per 100 m^2 in the Renous and Northwest Miramichi rivers, respectively, in 2013. Average large parr densities in 2012 were similar across rivers ranging from 2 (Renous) to 8 (Northwest) per 100 m^2 and similar again in 2013 (4 per 100 m^2 on the Renous and 5 per 100 m^2 on the Northwest). With the exception of the Northwest Miramichi, the average large parr densities in 2012 and 2013 were at or above the long term averages for the rivers since 1987 (Fig. 13).

Overall, juvenile salmon abundances have varied around higher average levels since the 1984 closure of the commercial fishery and the mandatory release of large salmon in the recreational fishery.

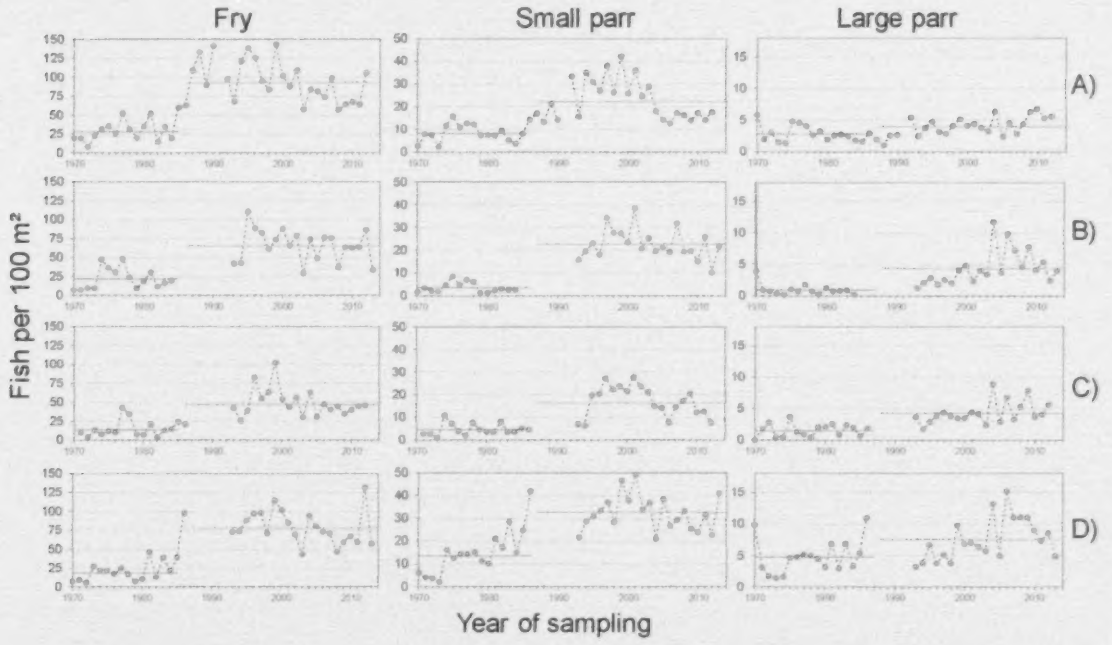


Figure 13. Annual average densities, expressed as fish per 100 m² of sampled area, for fry (left column), small parr (middle column), and large parr (right column) at sampled sites in the four major rivers of the Miramichi watershed: A) Southwest Miramichi, B) Renous River, C) Little Southwest Miramichi, and D) Northwest Miramichi, 1970 to 2013. Only sites in the Renous River and the Northwest Miramichi River were sampled in 2013. Horizontal solid line and the horizontal dashed line in each panel are the average densities corresponding to periods before and after, respectively, significant management changes were implemented to the commercial and recreational salmon fisheries in 1984.

SFA 16B

Surveys have been conducted consistently since the mid-1990s in four rivers of SFA 16B. In 2012, a total of 18 sites were surveyed on the Richibucto/Coal Branch, Buctouche, and Kouchibouguac rivers. In 2013, 12 sites were surveyed on the Richibucto, Buctouche, and Kouchibouguac rivers.

The average densities of salmon fry in 2012 ranged between 26 and 58 per 100 m^2 and were above the long term average since the management changes in 1998 for all the rivers sampled (Fig. 14). With the exception of the Kouchibouguac River, fry densities declined in 2013 to below the long term averages. With the exception of the Kouchibouguac River in 2012, parr densities were similar across rivers and across years (range 8 to15 parr per 100 m^2) and below the averages for the rivers since 1998 (Fig. 14).

Salmon fry densities of 40 per 100 m^2 were observed in the Buctouche River in 2000 following an adult salmon assessment the previous year that determined that conservation requirements had been met. Similar levels of fry were observed in the Buctouche, Cocagne, and Kouchibouguac rivers in 2005, suggesting that spawning requirements may have been achieved for those rivers in 2004. The density of salmon fry in the Kouchibouguac River was above 40 per 100 m^2 in 2012 and 2013; a possible indication that this river may have met its conservation requirement in 2011 and 2012.

While these levels of juvenile salmon are less than in the Miramichi River, direct comparisons of juvenile densities to other watersheds may not be appropriate given the notable differences in habitat between rivers. For example, many of the smaller rivers in SFA 16B have been characterized as low gradient with limited suitable spawning habitat.

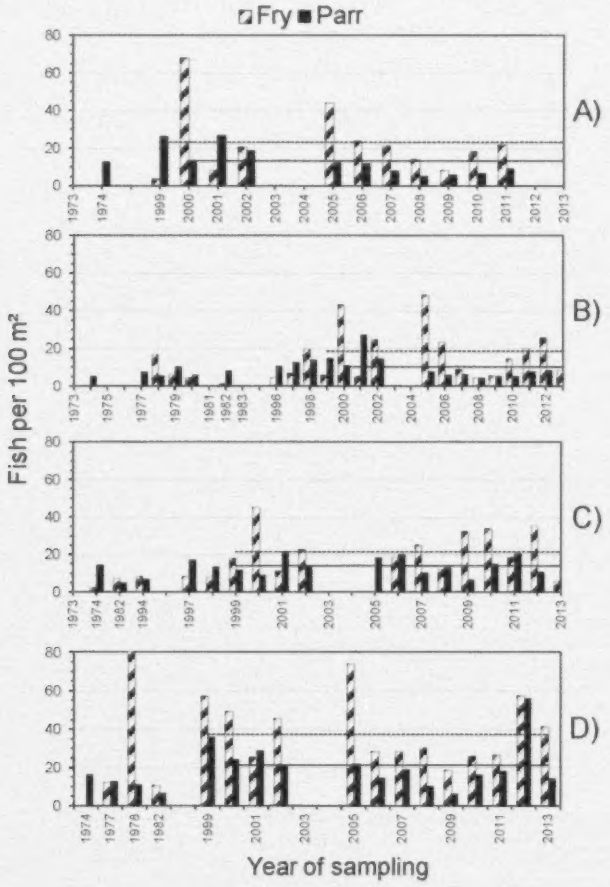


Figure 14. Average densities, expressed as fish per 100 m² of sampled area, for fry and parr (size groups combined) from sampled sites in four rivers of southeast New Brunswick (SFA 16B) for 1974 to 2013 sampling years. The rivers shown are: A) Cocagne, B) Buctouche, C) Richibucto/Coal Branch, and D) Kouchibouguac. The horizontal lines represent averages for fry (dashed) and parr (solid) in their respective rivers after the aboriginal and recreational fisheries were closed in 1998. The 1978 value for fry density (116 fish per 100 m²) for the Kouchibouguac River is not shown.

SFA 17

No continuous series of juvenile abundance indices are available for SFA 17. Most surveys conducted since 2000 have been done by NGOs and the province of PEI, directed at determining the presence of salmon and helping identify habitat problems. Because of small sample sizes in recent years, these survey results are of limited value in assessing current trends in freshwater production. Juvenile surveys conducted in 2000-2002 and in 2007-2008 found salmon in 28 and 22 rivers, respectively. Surveys in 2011 sampled salmon in an additional river, the Clyde (Appendix Figure 1, Appendix Table 1). However, given the lack of

comprehensive juvenile surveys in 2009-2011, it is possible that some rivers found to have salmon in 2007-2008 had lost their salmon populations by 2011.

SFA 18A

A change in strategy for the juvenile sampling coverage was implemented for the rivers of mainland Gulf-Nova in 2012. Prior to 2012 in SFA 18A, three sites were electrofished in West River (Antigonish), two sites in Barney's River, three sites in East River (Pictou), two sites in Wallace River and two sites in River Philip. In 2012 and 2013, the number of sites electrofished increased to six sites per river in West River (Antigonish), East River (Pictou) and River Philip, while the coverage of Barney's River and Wallace River was eliminated.

Fry density exceeded 29 fish per 100 m^2 in all three index rivers in 2012 and 2013 (Fig. 15). However, in the cases of East River (Pictou) and West River (Antigonish), fry densities have been lower in recent years compared to the 1990's and 2000's. Parr densities were lower than 38 fish per 100 m^2 in all three index rivers but were still comparable to earlier recent estimates with more than 20 parr per 100 m^2 (Fig. 15).

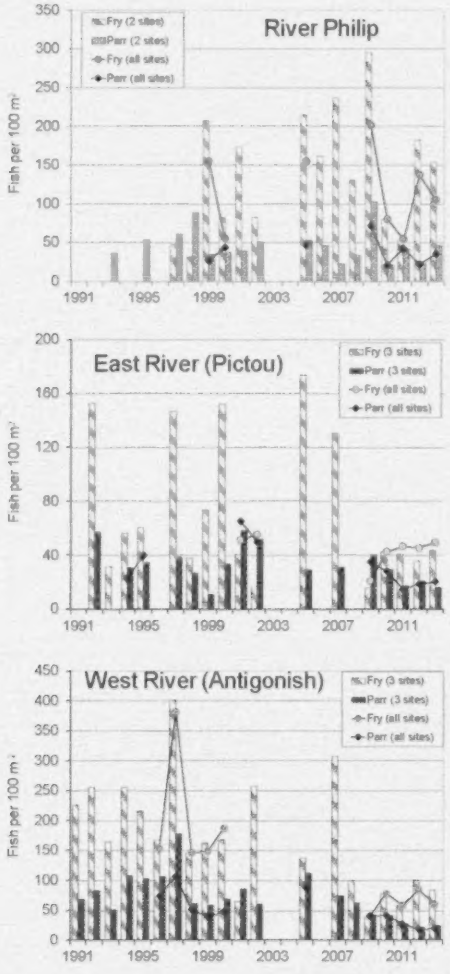


Figure 15. Average annual densities, expressed as fish per 100 m² of sampled area, for fry and parr (size groups combined) in three index rivers of mainland Nova Scotia (SFA 18A), 1991 to 2013.

SFA 18B

Surveys for juvenile salmon have been conducted annually at 5 to 13 sites in the Margaree River since 1990. Juvenile densities in the Margaree River have been generally high but with important annual variation. A 100-year flood occurred in the Margaree River in December 2010 and subsequently fry were absent at the three mainstem sites and present in only four of eight sampled tributary sites in the Margaree in 2011. By contrast, fry densities were high in fall 2012 confirming that spawner abundance was high in 2011 (Fig. 16). Fry and parr were found at all sites sampled in 2012 and 2013 (Fig. 16).

Fry densities have declined from the peak abundances in 2004 and 2005 and were at the lowest abundance in 2011 (Fig. 16). An increase in densities in 2012 following the good adult returns of 2011 was followed by another low density in 2013 relative to the recent time series (Fig. 16). Except for 2012, four of the five lowest values in fry densities occurred during the last five years compared to the 1990 to 2008 trend (Fig. 16).

Parr abundances have also declined from the peak value in 2005 (Fig. 16). Parr densities in 2011 were slightly higher than in 2009 and 2010, but densities for years 2009 to 2013 were half the densities of the 1990 to 2008 average (Fig. 16).

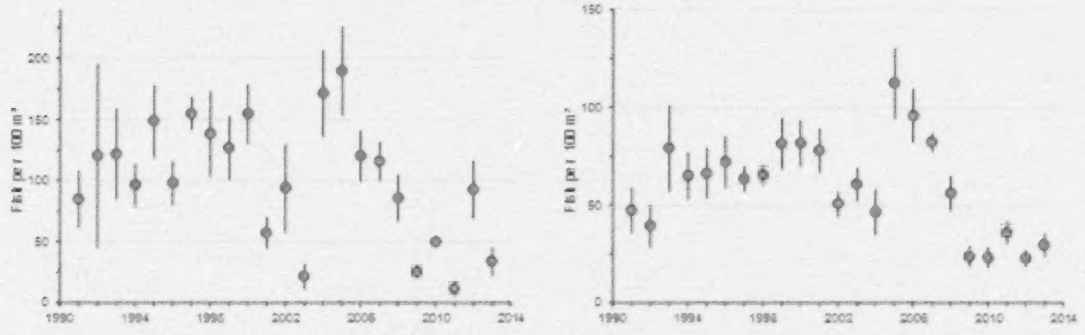


Figure 16. Annual densities (mean, standard error bars), expressed as fish per 100 m² of sampled area, for fry (left panel) and parr (right panel) in the Margaree River (SFA 18B), 1991 to 2013.

Smolt production estimates

Smolt monitoring programs have taken place in the past decade on the three major rivers of Gulf Region: Restigouche, Miramichi, and Margaree. All the assessments are based on mark and recapture experiments. Estimates are available for the Restigouche River overall and the Kedgwick River (major tributary of the Restigouche), for the Southwest Miramichi and the Northwest Miramichi, and the Margaree River. Smolt production estimates are scaled to the unit of rearing habitat (smolts per 100 m²). Smolt production estimates in 2013 were only available from the Kedgwick River.

The highest smolt production rate has generally been estimated for the Margaree River with very high production rates estimated for the Southwest Miramichi in 2010 and for the Kedgwick River and the Northwest Miramichi in 2011 (Fig. 17). There has been a tendency for smolt production to have increased in all monitored rivers over the period of assessment. Smolt production of 3 to 5 smolts per 100 m² is expected for these rivers.

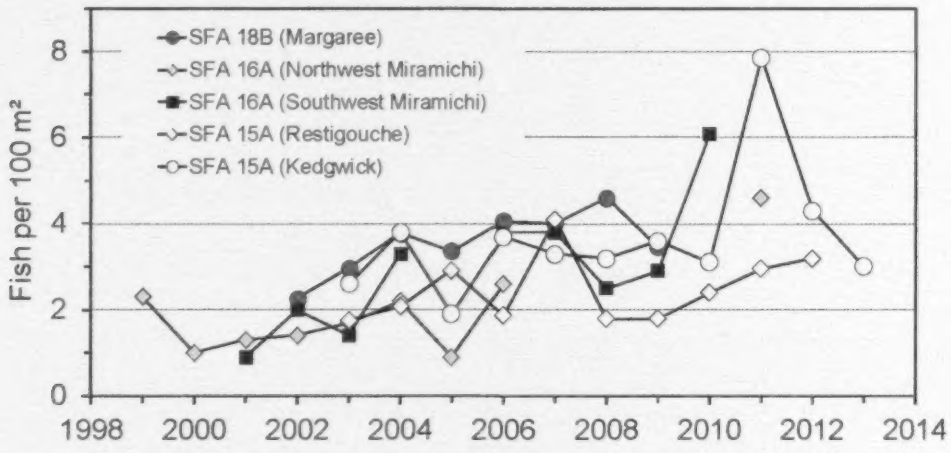


Figure 17. Smolt production, expressed as fish per 100 m² of wetted habitat area, from monitored rivers in Gulf Region, 1999 to 2013. Smolt production from the Kedgwick River (SFA 15A) is included in the total smolt production from the Restigouche River.

Management Considerations

One of the big challenges for Atlantic salmon fisheries managers is to develop fishing plans that exploit individual salmon stocks relative to their status. The challenge is even greater when considering that monitoring and assessments of status occur for a small number of the salmon rivers within the region. Recreational fisheries are presently managed on a province-wide basis with some area specific measures (closure of rivers in SFA 16B; catch and release only in section of the Northwest Miramichi) put in place to account for differences in stock size and status. The potential harvest of small salmon in recreational fisheries equates to the product of the recreational fishing licences sold and season retention limits with each licence; in 2013 this represented 164,000 tags issued when the estimate of total abundance of small salmon in 2013 in Gulf Region was in the range of 34,000 fish.

A management approach to adjust the potential harvest in rivers closer to the available abundance could be based on a classification system in which the number of fish which an individual angler can retain from a class of rivers varies with size and status of the resource. The information requirements for such a system include:

- Estimates of conservation requirements for individual rivers,
- Estimates of status of individual rivers (returns relative to conservation requirements),
- Estimates of average surpluses to conservation for individual rivers (average performance or forecasts of abundance), and
- A system that can manage allocations of harvests from individual rivers to correspond to stock status and estimated surpluses to conservation.

The first requirement (reference points for rivers) is available. At present, conservation requirements have been defined for 126 rivers in Gulf Region. The egg requirements are preferentially obtained from large salmon but in the assessment of status, eggs from all age groups are considered.

The second requirement (assessment of status in individual rivers) is not available. Monitoring and assessments of status occur for a small number of rivers although the largest salmon producing rivers in Gulf region are monitored. Indices of status based on trends in juvenile abundances or trends in catches and catch per unit of effort are available from more rivers than those assessed for adult returns but these indices do not yet equate to estimates of returns nor to attainment of conservation objectives.

The third requirement (estimates of surplus) is not available for all rivers but information for this could be obtained by proximate methods. River-specific conservation requirements equate to a measure of stock size. Based on the status of monitored rivers, which for Gulf Region are the largest salmon rivers in the region (Restigouche, Miramichi, Margaree), estimates of total abundance by size group for the corresponding Salmon Fishing Area could be calculated. The difference between estimates of total abundance for a region (SFA for example) and spawner requirements for the region would represent the available surplus. This is currently done by Salmon Fishing Area and these numbers are used for the international assessment and development of catch advice for the high seas fisheries at Greenland (ICES 2012). A choice would have to be made regarding the value of a small salmon for the fishery versus the value of the small salmon for conservation as presently the egg conservation requirements are translated into large salmon equivalents, although in assessment of stock status eggs from all size groups are included. Forecasts of abundance even one year forward are not realistic at this stage; marine survival is highly variable year on year and the associations between returns of 1SW in one year and returns of 2SW or large salmon in the subsequent year are very poor to non-existent in stocks where this has been examined. Use of abundance over a recent time period could be used, such as the average over the recent generation (5 to 6 years) and corresponding surplus potential derived from these values.

Finally, managing exploitation individually on the many small rivers in the region is a very difficult task. Many of the salmon rivers in the region are small with conservation requirements of less than 0.5 million eggs (equates to less than 100 large salmon spawners). Even if a system can be put in place that would allow the setting of annual quotas for rivers, the information and management requirements for such a system would be onerous for the over 126 rivers in the region with presently defined conservation requirements. An alternate approach to individual river management could be to group the rivers by their size, for example treating all rivers in a SFA or province that have less than 0.5 million eggs conservation requirement as a group of rivers, to which a specific group allocation could be defined. Progressively higher individual licence holder allocations could be provided on large rivers which have larger salmon populations and thus larger potential surpluses.

Sources of Uncertainty

Catches and harvests from aboriginal fisheries and recreational fisheries are undocumented or incomplete. Undocumented harvests in aboriginal fisheries are particularly of concern as large salmon allocations are provided in agreements and licences. With the exception of the Restigouche River and the Nepisiguit River in SFA 15, there are no angling catch data for the other smaller rivers in SFA 15 nor for any rivers in SFA 16 including the Miramichi River. In SFA 18 (Gulf NS), angling catches are estimated from survey card reports but the return rate remains low (< 50%), even when prompted by reminder mailings. Adjustments for underreporting are applied but it is not known if this results in a bias due to differences in angling effort and success of reporting versus non-reporting anglers. Assumptions about harvest levels and catch and release mortality are required to assess spawning escapements and compliance with conservation objectives. Depending on the accuracy of the assumed levels of removals, the level of conservation attainment may be under or over estimated. Evaluation of

the effectiveness of management measures, such as the benefits of catch and release measures in the Northwest Miramichi or of alternate management options such as season tag reductions, is consequently difficult.

Adult assessments are only conducted for the five largest rivers in Gulf Region. These assessments have differing levels of data needs and uncertainties. The assessment of the Margaree River depends upon annual angling catch and effort data to which a historical catch rate coefficient is assumed to still be appropriate. The assessment of the Restigouche River is based on angling catches and assumed exploitation rates unadjusted for changes in effort. Supplementary data from spawner counts in the fall in the main tributaries of the river, and generally excluding the main stem, are also used. The assessment of returns to the Nepisiquit River is based on redd counts and a conversion factor from redds to adult fish that has not been verified in recent years. Adult returns to the Miramichi are assessed annually using mark and recapture experiments of varying precision depending upon the annual success of monitoring activities.

Status of Atlantic salmon in other rivers depends upon indices of angling catch and effort (SFA 18) and/or juvenile abundance indices, the latter being qualitative indicators of previous years' spawning escapement (SFA 15 to 18). Catch rates from angling data are difficult to compare among rivers due to differences in run timing of salmon, different sizes of runs and the absence of any measure of variations in catchability with river size. It is not possible to compare juvenile salmon abundance indices directly among rivers as there is no standardization of the indices for habitat characteristics (including habitat type, elevation, gradient, stream width, stream order, latitude, and water nutrients) which have been shown to be associated with carrying capacity of juveniles. Temporal trends in juvenile abundance in individual rivers are considered relevant although small sample sizes for some rivers result in large intra- and inter-annual variations.

In SFA 17, adult returns and spawners are estimated from redd counts. The conversion of redd counts to spawners is based on data from a single river in a single year. Uncertainty in the ratio of redd counts to returns leads to uncertainty in return and spawner estimates. Since the 2000s, most electrofishing work has been directed at determining salmon status in smaller streams. There are no time-series which reliably track trends in juvenile salmon abundance.

The absence of adult assessment data in an index river in southeast New Brunswick (SFA 16B) and 15C (Acadian Peninsula in New Brunswick) and the fallback to using juvenile indices as an index of stock status relative to conservation makes it difficult to advise fisheries management on fisheries options in these small rivers. Juvenile indices from the Buctouche River suggest that conservation may have been met in only a few years since monitoring began, but the level of harvestable surplus when it occurred is presumed to be small.

Periodic synoptic surveys as conducted in 2008 and 2009 show that salmon were found in over 115 rivers and streams in Gulf Region, the majority of these were small rivers that are not even intermittently monitored for juveniles or through catch statistics (Appendix Table 1; Appendix Figure 1).

CONCLUSIONS

Returns of large salmon to assessed rivers in Gulf Region in 2012 were among the lowest on record in the major index rivers monitored in SFAs 15 (Restigouche), 16 (Miramichi) and 18 (Margaree). This followed on the high abundance of small salmon noted in these rivers in 2011. This contrasts with the situation in 2011 when high abundance of large salmon had been preceded by greatly improved returns and abundance of small salmon in 2010 in most areas relative to the previous fifteen years. The improved returns in 2010 and 2011 of small salmon

and large salmon reflected improved marine survival of the smolts that emigrated in 2009 relative to those of previous years.

Returns of large salmon in 2013 were at approximately the same levels as those estimated in 2012 in the Gulf Nova Scotia (SFA 18) and the Miramichi River (SFA 16), and among the lowest of the time series. On contrast, the large salmon return in the Restigouche River (SFA 15) was improved in 2013 relative to 2012. Returns of large salmon were not as low as was expected given the near record low returns of small salmon in all areas in 2012, i.e. the expectation was for lower returns in 2013 than had been observed in 2012.

The striking feature in the stock status of salmon in Gulf Region is the region wide low abundance of small salmon observed in 2012 and 2013, the low abundance of large salmon in all areas in 2012 and for two areas (SFA 16 and SFA 18) the low returns of large salmon in again in 2013. The relative changes in abundance in 2012 and 2013 relative to 2011 for index rivers in Gulf Region show a consistent low return in the last two years relative to the high returns observed in 2011, for both small and large salmon (Fig. 18).

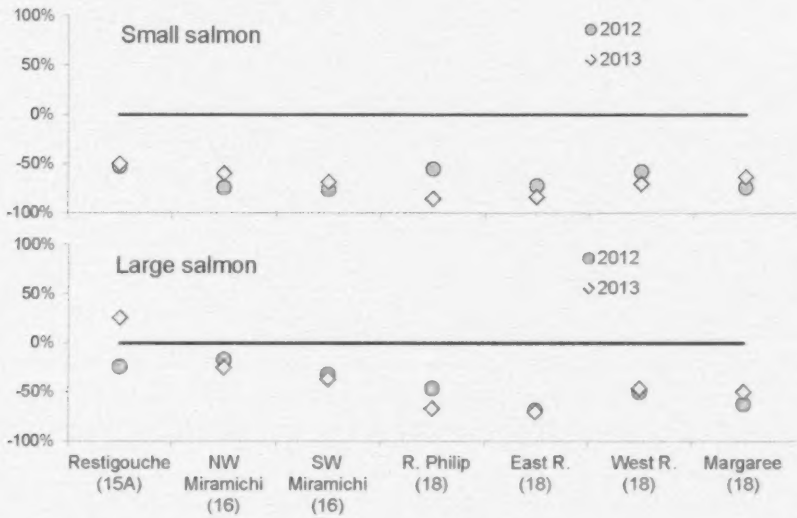


Figure 18. Relative change in abundance indicators in 2012 and 2013 from 2011 of small salmon (upper panel) and large salmon (lower panel) for seven rivers of Gulf Region. Abundance is in terms of estimates of returns except for R. Philip (18), East River (18) and West River (18) which are in terms of catch rates per unit of angling effort.

The eggs in the returns to rivers (before inriver removals) in 2012 were below the conservation requirements for the Restigouche River (NB SFA 15), the Southwest and Northwest Miramichi rivers (SFA 16) but were just above requirements in the Margaree River (SFA 18). In 2013, the eggs in the returns exceeded the conservation requirements in the Restigouche River and the Margaree River but they were below conservation requirements for both the Northwest and Southwest Miramichi rivers. This contrasts with the situation in 2011 when even after accounting for removals, spawning escapements in all assessed rivers (Restigouche, Nepisiguit, Northwest Miramichi, Southwest Miramichi, and Margaree) exceeded their conservation requirements. Several small rivers on the northeast tip of SFA 17 likely met or exceeded their conservation requirements; salmon return to rivers in this region very late in the fall just prior to spawning.

Catch and harvest data from all SFAs are incomplete or entirely lacking in some areas. Undocumented harvests in aboriginal fisheries and incomplete or absent statistics on catches and harvests in the recreational fisheries are particularly problematic. Assumptions about harvest levels and catch and release mortality are required to assess spawning escapements and compliance with conservation objectives. Depending on the accuracy of the assumed levels of removals, the level of conservation attainment may be under or over estimated. The absence of these data makes it impossible to evaluate the effectiveness of management measures.

Exploitation rates (fishing related losses) on large salmon in Gulf Region overall are estimated to be quite low and in the range of 3% to 6% of total returns since the management measures introduced in 1984 (DFO 2012). Exploitation rates on small salmon are estimated to be in the range of 17% to 40% annually although these estimates are based on assumptions of catch rates and losses in absence of reliable and complete harvest data. Exploitation rates in individual rivers will vary from these depending upon the intensity of the aboriginal FSC and recreational fisheries.

The majority of salmon bearing rivers in SFA 17 continue to be negatively impacted by sediment from erosion, pesticide runoff, competition with introduced rainbow trout, and habitat fragmentation due to inadequate fish passage.

Atlantic salmon occupy 115 rivers (that empty into estuaries) in Gulf Region and with exception of some of the rivers in SFA 17, juvenile abundances are sustained at moderate to high levels. Smolt assessments in the three main rivers in Gulf Region indicate that the total production from freshwater has generally improved over the past decade and smolt production rates are within the range (3 to 5 smolts per 100 m^2) expected for salmon producing rivers in the Maritime Provinces. Abundance of adult salmon is constrained by low marine survival, a phenomenon which is widespread for Atlantic Salmon stocks from eastern North America.

SOURCES OF INFORMATION

This Science Advisory Report is from the Regional science peer review meeting of February 26-27, 2014 on the Stock status of Atlantic salmon (*Salmo salar*) in DFO Gulf Region (Salmon Fishing Areas 15 to 18). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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Breau, C., Chaput, G., LeBlanc, P., and Mallet P. 2009. Information on Atlantic salmon (*Salmo salar*) from Salmon Fishing Area 18 (Gulf Nova Scotia) of relevance to the development of a COSEWIC status report. DFO Can. Sci. Advis. Secr. Res. Doc. 2009/076: iv + 53 p.

CAFSAC. 1991a. Definition of conservation for Atlantic salmon. CAFSAC Adv. Doc. 91/15.

CAFSAC. 1991b. Quantification of conservation for Atlantic salmon. CAFSAC Adv. Doc. 91/16.

Cairns, D.K., Guignion, D.L., Dupuis, T., and MacFarlane, R.E. 2010. Stocking history, biological characteristics, and status of Atlantic salmon (*Salmo salar*) on Prince Edward Island. DFO Can. Sci. Advis. Secr. Res. Doc. 2010/104. iv + 50 p.

Cairns, D.K., MacFarlane, R.E., Guignion, D.L., and Dupuis, T. 2012. The status of Atlantic salmon (*Salmo salar*) on Prince Edward Island (SFA 17) in 2011. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/090. iv + 33 p.

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COSEWIC. 2010. COSEWIC assessment and status report on the Atlantic salmon *Salmo salar* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xlvii + 136 pp.

DFO. 2008. 2008-2012 - IFMP - Atlantic Salmon - DFO - Gulf - Integrated Fisheries Management Plans. 45 p.

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DFO. 2013. Atlantic Salmon (*Salmo salar*) returns to the Miramichi River (NB) for 2012. DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/009.

Douglas, S.G., Chaput, G., Hayward, J., and Sheasgreen, J. 2013. Assessment of Atlantic Salmon (*Salmo salar*) in Salmon Fishing Area 16 of the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/104. v + 63 p.

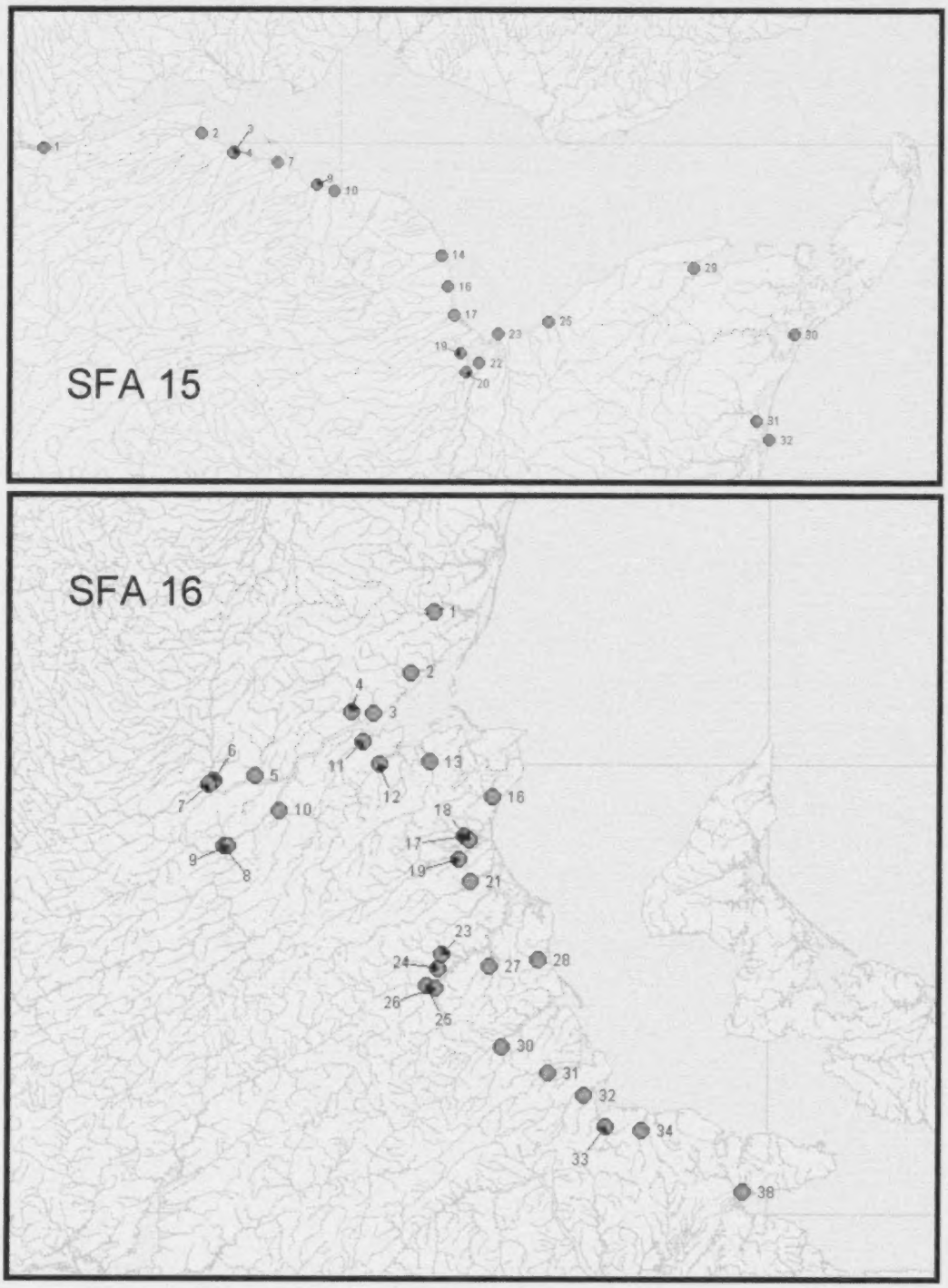
APPENDICES

Appendix Table 1. List of rivers and their characteristics with confirmed Atlantic Salmon presence by Salmon Fishing Area in DFO Gulf Region. Source of evidence of salmon presence include adults (Adult) either from angling, surveys or redd counts and from juvenile monitoring (Juvenile).

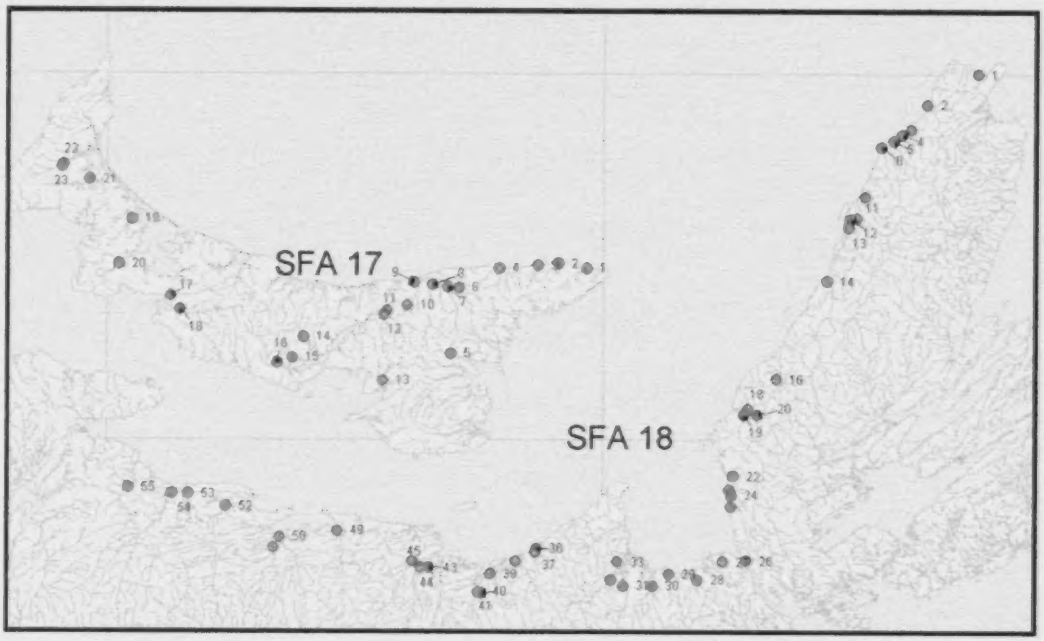
Map index number	SFA	River name	Longitude (W)	Latitude (N)	Egg requirement (million)	Drainage area (km²)	Fluvial area (million m²)	Adult	Juvenile
1	15	Restigouche	-66.783	47.991	44.93	6,589	26.744	X	X
2	15	Eel River	-66.367	48.017	1.01	116	0.422	X	X
3	15	Charlo	-66.283	47.983	1.44	400	0.600	X	X
4	15	South Charlo	-66.283	47.985	na	na	na	na	X
7	15	Benjamin	-66.167	47.967	0.58	161	0.241	X	X
9	15	Louison River	-66.063	47.927	na	na	na	na	X
10	15	Jacquet	-66.017	47.917	2.72	510	1.135	X	X
14	15	Elmtree	-65.732	47.805	na	na	na	na	X
16	15	Nigadoo	-65.717	47.750	0.6	168	0.252	X	X
17	15	Millstream	-65.700	47.700	0.83	229	0.344	X	X
19	15	Tetagouche	-65.683	47.633	0.72	364	0.299	X	X
20	15	Middle (Gloucester)	-65.667	47.600	2.28	401	0.950	X	X
22	15	Nepisiguit	-65.633	47.617	9.54	2,312	3.973	X	X
23	15	Bass (Gloucester)	-65.583	47.667	0.71	198	0.297	X	X
25	15	Teagues Brook	-65.449	47.689	na	na	na	na	X
29	15	Caraquet	-65.067	47.783	1.34	373	0.560	X	X
30	15	Pokemouche	-64.800	47.667	0.60	481	0.248	X	X
31	15	Little Tracadie	-64.900	47.517	0.69	192	0.289	X	X
32	15	Tracadie	-64.867	47.483	1.44	527	0.601	X	X
1	16	Tabusintac	-65.103	47.338	1.98	704	0.824	X	X
2	16	Burnt Church	-65.179	47.204	0.72	135	0.299	X	X
3	16	Oyster	-65.304	47.113	na	na	na	na	X
4	16	Bartibog	-65.372	47.115	2.72	512	1.135	X	X
5	16	Northwest Millstream	-65.692	46.974	1.20	210	0.479	X	X
6	16	Northwest Miramichi	-65.826	46.963	20.10	2,307	8.230	X	X
7	16	Little Southwest Miramichi	-65.845	46.953	19.70	1,345	8.070	X	X
8	16	Renous	-65.792	46.816	14.00	1,429	5.820	X	X
9	16	Southwest Miramichi	-65.781	46.816	70.90	5,840	29.530	X	X
10	16	Barnaby	-65.611	46.896	3.10	490	1.304	X	X
11	16	Napan	-65.337	47.050	0.28	115	0.115	X	X
12	16	Black (Northumberland)	-65.280	47.000	0.67	277	0.277	X	X
13	16	Bay du Vin	-65.117	47.005	0.68	284	0.284	X	X
16	16	Riviere au Portage	-64.910	46.928	na	na	na	na	X
17	16	Black (Kent)	-65.004	46.840	0.82	343	0.343	X	X
18	16	Rankin Brook	-64.986	46.831	na	na	na	na	X

Map index number	SFA	River name	Longitude (W)	Latitude (N)	Egg require-ment (million)	Drainage area (km²)	Fluvial area (million m²)	Adult	Juve-nile
19	16	Kouchibou-guac (Kent)	-65.020	46.790	1.41	389	0.588	X	X
21	16	Kouchibou-guacis	-64.980	46.739	1.32	360	0.549	X	X
23	16	Molus	-65.073	46.578	na	na	na	na	X
24	16	Bass	-65.089	46.545	na	na	na	na	X
25	16	Richibucto	-65.125	46.508	2.94	1,292	1.226	X	X
26	16	Coal Branch	-65.093	46.502	na	na	na	na	X
27	16	Saint Nicholas	-64.919	46.551	na	na	na	na	X
28	16	Chockpish	-64.755	46.566	0.31	129	0.129	X	
30	16	Buctouche	-64.874	46.373	1.59	628	0.661	X	X
31	16	Cocagne	-64.724	46.314	0.68	333	0.283	X	X
32	16	Shediac	-64.605	46.264	0.52	219	0.216	X	X
33	16	Scoudouc	-64.532	46.194	0.35	159	0.146	X	X
34	16	Aboujagane	-64.415	46.186	0.29	120	0.120	X	X
38	16	Gaspereau (Westmorland)	-64.083	46.050	0.41	170	0.170		X
1	17	North Lake Creek	-62.068	46.468	0.15	48	0.062	X	X
2	17	Priest Pond Creek	-62.179	46.481	0.08	25	0.033	X	X
3	17	Cross Creek	-62.263	46.475	0.14	44	0.058	X	X
4	17	Naufrage	-62.417	46.469	0.14	44	0.057	X	X
5	17	Cardigan	-62.519	46.205	0.14	45	0.058		X
6	17	St. Peters	-62.581	46.415	0.14	45	0.058	X	X
7	17	Midgell	-62.626	46.416	0.20	64	0.084	X	X
8	17	Morell	-62.686	46.424	0.57	171	0.237	X	X
9	17	Bristol (Berrigans) Creek	-62.759	46.427	0.13	41	0.054	X	X
10	17	Head of Hillsborough	-62.788	46.368	0.17	53	0.070		X
11	17	Pisquid	-62.870	46.351	0.15	48	0.062	X	X
12	17	Clarks Creek	-62.885	46.342	0.15	46	0.061		X
13	17	Vernon	-62.886	46.161	0.22	69	0.090		X
14	17	North	-63.151	46.226	0.31	99	0.130	X	X
15	17	Clyde	-63.263	46.195	0.13	42	0.055		X
16	17	West	-63.471	46.209	0.14	43	0.185	X	X
17	17	Wilmot	-63.741	46.391	0.26	83	0.109		X
18	17	Dunk	-63.778	46.369	0.46	166	0.193	X	X
19	17	Trout (Tyne Valley)	-63.897	46.601	0.15	48	0.063	X	X
20	17	Little Trout	-63.950	46.479	0.07	21	0.028	X	X
21	17	Trout (Coleman)	-64.066	46.710	0.34	107	0.140	X	X
22	17	Cains Brook (Mill River)	-64.172	46.749	0.05	31	0.023	X	X
23	17	Carruthers Brook (Mill River)	-64.178	46.744	0.09	48	0.035	X	X
1	18	Salmon	-60.494	47.000	na	na	na	na	X
2	18	Blair	-60.699	46.917	0.23	58	0.097	X	

Map index number	SFA	River name	Longitude (W)	Latitude (N)	Egg requirement (million)	Drainage area (km²)	Fluvial area (million m²)	Adult	Juvenile
3	18	Red	-60.766	46.850	0.14	35	0.059		X
4	18	Grande Anse	-60.799	46.833	0.20	51	0.085	X	X
5	18	Mackenzies	-60.833	46.817	0.30	75	0.124	X	X
6	18	Fishing Cove	-60.883	46.800	0.13	31	0.052	X	
10	18	Chéticamp	-60.949	46.667	0.77	298	0.322	X	X
11	18	Aucoin Brook	-60.981	46.607	na	na	na	na	X
12	18	Fiset Brook	-61.005	46.603	na	na	na	na	X
13	18	Farm Brook	-61.015	46.582	na	na	na	na	X
14	18	Margaree	-61.099	46.433	6.71	1,100	2.798	X	X
16	18	Broad Cove	-61.303	46.165	na	na	na	na	X
18	18	Northeast Mabou	-61.416	46.083	1.02	254	0.424	X	X
19	18	Southwest Mabou	-61.433	46.067	0.37	123	0.154	X	X
20	18	Mabou	-61.383	46.067	0.56	188	0.235	X	X
22	18	Judique Intervale Brook	-61.474	45.900	0.18	44	0.074	X	X
23	18	Graham	-61.491	45.861	na	na	na	na	X
24	18	Campbells Brook	-61.484	45.849	na	na	na	na	X
25	18	Chisholm Brook	-61.483	45.817	0.07	17	0.028	X	X
26	18	Mill Brook (Strait of Canso)	-61.422	45.669	na	na	na	na	X
27	18	Wrights	-61.518	45.667	na	na	na	na	X
28	18	Tracadie	-61.616	45.617	0.13	120	0.053	X	
29	18	Afton	-61.733	45.633	0.05	43	0.019	X	X
30	18	Pomquet	-61.799	45.600	0.19	176	0.077	X	X
31	18	South	-61.916	45.600	0.23	217	0.095	X	X
32	18	West (Antigonish)	-61.966	45.617	1.15	353	0.480	X	X
33	18	North	-61.939	45.666	na	na	na	na	X
36	18	Vameys Brook	-62.269	45.701	na	na	na	na	X
37	18	Baileys Brook	-62.270	45.692	na	na	na	na	X
38	18	Barneys	-62.349	45.667	0.51	156	0.213	X	X
39	18	French (Merigomish)	-62.449	45.633	0.42	128	0.174	X	X
40	18	Russell Brook	-62.488	45.580	na	na	na	na	X
41	18	Sutherlands	-62.499	45.583	0.16		0.067	X	X
43	18	East (Pictou)	-62.699	45.650	1.75	536	0.729	X	X
44	18	Middle (Pictou)	-62.733	45.650	0.71	217	0.295	X	X
45	18	West (Pictou)	-62.766	45.667	0.80	245	0.333	X	X
49	18	River John	-63.066	45.750	0.95	292	0.397	X	X
50	18	Waughs	-63.299	45.733	0.75	230	0.313	X	X
51	18	French	-63.326	45.704	na	na	na	na	X
52	18	Wallace	-63.516	45.817	1.50	458	0.623	X	X
53	18	Pugwash	-63.666	45.850	0.59	182	0.247	X	X
54	18	River Philip	-63.733	45.850	2.31	726	0.962	X	X
55	18	Shinimicas	-63.909	45.866	na	na	na	na	X



Appendix Figure 1. Location of rivers with confirmed Atlantic Salmon presence by SFA in DFO Gulf Region. Indices reference rivers in Appendix Table 1.



Appendix Figure 1 (continued).

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